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E.P. Podrushnyak and E.I. Suslov

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E.P. Podrushnyak and E.I. Suslov
Institute of Gerontology, USSR
Academy of Medical Sciences, Kiev

In phylogenesis, bone tissue was formed as a protective adaptation, /841* which opposes gravity and pressure [3]. It is natural to assume that, in hypokinesia, disturbance of the bone structure becomes evident. An effect of hypokinesia on bone structure can be achieved, both in extreme situations (fixed body position, strict bed rest, etc.), or in the process of living. It is evident that muscle activity decreases somewhat with age and that this creates conditions for hypodynamia. Thus, regardless of how the conditions of hypokinesia arise, in the final analysis, the problem itself, whether bone tissue counters environmental factors in a changed situation, is decisive.

Method

We used two methods of study of bone tissue: microroentgenography /842 and X-ray structural analysis.

The optical density (degree of blackening) of X-ray photographs of the heel bones of nine young people from 24 to 29 years of age was found by microroentgenography. These measurements were made before and after hypokinesia (strict bed rest regimen for 16-37 days). The optical density of the X-ray photographs was determined by photometry. The photometric results were recorded automatically, in the form of a curve. By comparing the optical densities of roentgenograms of bone tissue before and after hypokinesia, the relative concentration of bone matter under these conditions can be decided.

The theoretical basis of microroentgenography is the principle of absorption of X-rays [6].

*Numbers in the margin indicate pagination in the foreign text.

Bone tissue of 25 corpses of healthy people who died from various trauma, ages 18 to 70 years, was studied by X-ray structural analysis.

The essence of X-ray structural analysis [1, 2] is the study of the structure of the crystalline matter, by means of X-ray interference.

Monochromatic X radiation of copper, with a nickel filter, was used in the study. We studied 3 X 5 X 30 mm pieces of bone tissue, taken from the cortical layer of the diaphysis of the femur.

The bone tissue was studied in URS-50-1M X-ray unit, with a GUR-4 goniometric attachmen in which the bone fragments were rotated with respect to a narrow X-ray beam. The interference maxima were transferred automatically to the graph paper of the recording potentiometer.

Results

As a result of the microroentgenographic studies, it was determined that, in hypokinesia (strict bed rest) for 16-37 days, the bone matter density of the heel bone of part of the test subjects decreased but, on the contrary, that of the rest of the test subjects increased.

Even by visual analysis of the X-ray photographs, it could be seen that the bone matter concentration of persons with a high (before hypokinesia) initial density decreased noticeably after hypokinesia; the degree of decrease increased with observation time. The contours of the bones became thin and open, expansion of the voids between the bone structures was noticed; therefore, all the characteristics of osteoporosis were observed.

On the contrary, the concentration of bone matter of test subjects with relatively low initial bone density increased, which is consistent with bone fractures, with a decrease in the openings between the bone structures.

In photometry of the X-ray photographs of the heel bones, the same regularity was established. In this case, if the maximum bone tissue

density of the test subjects before the study is assumed to be 100 units, the minimum initial density of the other test subjects, correspondingly, became 72.5-82.5 relative units.

For the test subjects with a high initial bone density (close to 100 units), a decrease to 80-85 units was observed in 16 days; after 37 days of study, the density decreased to 70.5-80.0 units. At the same time, for persons with initial bone tissue density of 72.5-82.5 units, after 16 days in hypokinesia, the concentration of bone matter increased to 90 units, and it became 90-95 units after 37 days. Thus, for test subjects with high initial known density, in the observation period (37 days), there was an average 20-25% decrease in concentration of bone matter. The density of bone matter with low initial concentration increased by an average of 20%. Thus, the response to hypokinesia of different persons was not the same but, frequently, it was directly opposite.

It now is important to state something on the mechanism of development of such a response of the body in the state of bone tissue in hypokinesia. Further study in this direction evidently will assist in deciphering the essence of this phenomenon.

It was determined in the study that the expression of osteoporosis of the bone tissue in hypokinesia can occur in a relatively short period of time in healthy young people while, usually, it develops only with age. It was described long ago in the literature that osteoporosis occurs in the elderly, but it has not yet been exactly determined whether there is a change here in the submicroscopic bone structure, particularly, of its crystal component, hydroxyapatite [3, 6], the concentration and crystal structure of which determines the bone strength, to a considerable extent. We used X-ray structural analysis to solve this problem.

As a result of X-ray structural analysis, three interference maxima were obtained. The first maximum is observed at an angle of 26°, the second at 32° and the third near 40°. The first peak of the recording, which corresponds to an angle of 26°, was the most distinct. The other peaks of the recording were washed out (not distinctly expressed). This /843

type of X-ray crystallogram, according to data in the literature, is characteristic of bone hydroxyapatite [6].

In comparing the roentgenograms (crystallograms) of the hydroxyapatite of people of different ages, some difference in the intensity of the interference maxima and their expression was noted. It was determined here that the intensity of the interference maxima increases insignificantly up to age 20-25. Sharp, high X-ray crystallogram peaks appear most often at this age and, at ages 25-60, the intensity of the interference maxima remained nearly unchanged. For people over 60, a decrease in intensity of the interference maxima is noted.

In analysis of the X-ray crystallograms, it was found that the dimensions of the hydroxyapatite crystals changed little with age.

Therefore, it was determined that stabilization of the crystal structure of hydroxyapatite, i.e., formation of its crystals, occurs up to 20-25 years of age. From 25 to 60 years of age, the crystal lattice is in a stable state but, afterwards, X-ray structural analysis records a decrease in hydroxyapatite density, which is confirmed by decreases in intensity of the interference maxima.

In conclusion, it should be noted that bone tissue, which is a highly dynamic structure, can change, both with age, and, even in a relatively short time. The change of body position (state of hypokinesia) relative to the gravitational field leads to substantial disturbances of the bone structure (density). In this case, changes in the bone tissue of different people are different. Inadequate (antithetical) responses of the bone tissue to hypodynamia have been found. It is evident that this circumstance should be taken into account in the assignment of people to work associated with the state of hypokinesia.

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